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Options for including LULUCF activities in a post-2012 international climate agreement

Part I – Synopsis of LULUCF under the Kyoto Protocol and Marrakech Accords and criteria for assessing a future agreement

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The inclusion of land use, land-use change and forestry related activities as options to contribute to meeting commitments under the Kyoto Protocol has been contentious. Yet, it can be argued that the inclusion of these activities under specific rules has been crucial for the agreement on the general framework to implement the Protocol. The decisions adopted at Marrakech in 2001 provide guidance for the first commitment period of the Protocol (2008 – 2012). In particular, decisions relating to LULUCF have been explicitly adopted for this period. This history suggests that LULUCF will play a substantial role in the negotiations for the future. Such negotiations will in all probability continue to deal with political and technical complexities leading to the design of a system for accounting for emissions and removals from LULUCF.

1 Introduction

Achieving the overall objective of the United Nations Framework Convention on Climate Change (UNFCCC) of avoiding "dangerous interference" with the global climate system may require that both LULUCF as well as emissions from fossil fuel burning are addressed.

Between 1989 and 1998 the removal of carbon from the atmosphere by terrestrial ecosystems has been estimated to average 2.3 GtC/year (IPCC, 2000) or nearly 30% of emissions from all anthropogenic sources. Emissions from carbon pools of terrestrial ecosystems – primarily due to land use change - amount to 1.6 GtC/year over the 1990's (IPCC, 2000) or about 20% of emissions from all anthropogenic sources. Given the significance of these emissions and removals and the potential to influence them with policy measures, it is important to explore the inclusion of land use, land-use change and forestry (LULUCF) in future international climate change agreements.

If LULUCF is to be included in climate change mitigation efforts, it is important to address the considerations raised in the present volume concerning the options and the design of the

accounting system for LULUCF. This will help to assure that the climatic benefits of LULUCF actions are real; their crediting is fair and their social and environmental effects are beneficial. In this light, it is important to take a step back and assess the way in which LULUCF was included in the Kyoto Protocol's first commitment period, the advantages and disadvantages of this approach, and the reasons why certain paths were taken in the decision making.

Under Article 3.3 of the Kyoto Protocol (KP) it is mandatory to report direct human-induced afforestation, reforestation and deforestation activities since 1990. Under Article 3.4, during the first commitment period, reporting of forest management, cropland management, grazing land management, and revegetation is voluntary. The Article 3.3 activities were agreed to in 1997 at the Third Conference of Parties (COP3), whereas Article 3.4 activities were only specified when COP6 reconvened in Bonn in 2001.

The framework finally accepted at COP7 in Marrakech is a negotiated solution produced by an evolving political process that had to deal with considerable scientific uncertainty. It has the great advantage of having been agreed to, and has in general allowed the negotiations to turn to other pressing issues. Nevertheless, few would dispute that simpler or more cost-effective ways (e.g. in terms of monitoring and reporting) may exist to include LULUCF in support of the ultimate objective of the Convention. Additionally the main source of LULUCF emissions, deforestation in developing countries, is not covered under the agreement: the Marrakech Accords include only afforestation and reforestation as eligible land-use activities under the CDM. Upcoming negotiations on a post-2012 agreement provide an opportunity to reassess, extend the list of eligible LULUCF activities, and possibly simplify the manner in which LULUCF activities are included in the international climate change regime.

The original provisions for the inclusion of LULUCF were agreed to at COP3 in Kyoto under time pressure and without the support of a credible scientific basis. Furthermore, the text of the Kyoto Protocol did not set specific rules as to how LULUCF emissions and removals would be incorporated into the accounting system. The Task of establishing specific rules was mandated to the Subsidiary Body for Scientific and Technological Advice (SBSTA of the UNFCCC). In 1998, SBSTA invited the Intergovernmental Panel on Climate Change (IPCC) to produce a Special Report on LULUCF, in order to support SBSTA's development of the rules. This Special Report provided options for definitions of terms relating to afforestation, reforestation and deforestation, for the inclusion of additional activities under Article 3.4, for GHG accounting rules of LULUCF activities, and discussed the implications of choices of definitions and accounting rules.

The present paper argues that future negotiations should first consider rules for LULUCF and then agree on targets. Targets can be set taking into consideration the desired stabilisation level of GHGs, national circumstances, and what the LULUCF rules mean for individual Parties. This may imply the need for increased consensus on what can reasonably be counted towards commitments as a result of human activity.

We assume that a future international climate agreement applicable to the period after 2012 will be under the UNFCCC, which specifically refers not only to *emissions by sources* but also to *removals by sinks*. We also assume that coverage of LULUCF activities will continue to include agriculture, forestry, and other land uses[1].

[1] This is consistent with the prospective IPCC 2006 inventory guidelines (agreed in outline by the IPCC at its 21st session in 2003) which merge the categories *Agriculture* and *Land-use Change and Forestry* to create one sector (*Agriculture, Forestry and Other Land Use or AFOLU*).

The set of papers in this special issue should be of interest to those involved in the negotiations toward a future climate agreement beyond 2012, as well as to the wider audience including researchers, environmental and business NGOs, GHG emitters, and land managers.

While the collection of papers in this special issue outlines options on how LULUCF emissions and removals might be included in an international climate agreement beyond 2012, it does not focus on ways of allocating overall emission targets to countries. The time frame of interest begins in 2013, after the end of the first commitment period. The issue of long-term stabilisation of atmospheric greenhouse gas (GHG) concentrations – the ultimate aim of the UNFCCC - is not treated explicitly, although the intent is to develop rules that effectively contribute to such stabilization and can be applied in the long term. The special issue focuses on carbon, because many of the controversial LULUCF discussions have focused on carbon stock changes. Non-CO_2 gases in agriculture are accounted for in other inventory categories and the same could be done for non-CO_2 gases from forest lands.

The special issue is structured as follows: Following a brief review of the special challenges to international climate policy presented by LULUCF (Section 2), this paper explains how LULUCF has been handled in the first commitment period are explained (section 3). Then we present objectives for including LULUCF post 2012, including both climate-related and other objectives, and discuss practical considerations that may be important for the successful inclusion of LULUCF (section 4). These objectives and considerations are used as criteria for evaluating the options presented in the other papers. We aim to do this in a policy-relevant fashion without being prescriptive by suggesting a preferred approach.

2 How is LULUCF different from other sectors?

The UNFCCC deals with five economic sectors that are the sources of greenhouse gases (GHG) in the atmosphere. These sectors are energy, industrial processes, agriculture, LULUCF and waste. GHG removals from the atmosphere occur only in LULUCF, because of biomass growth. This results in specific accounting characteristics which make the LULUCF sector distinct from the rest.

LULUCF uniquely presents no less than *five*[2] avenues to reduce net GHG emissions, namely:

- provision of renewable energy;
- substitution for more fossil carbon intensive products;
- reduction of emissions of non-CO_2 gases (e.g. from agriculture);
- carbon sequestration through enhancement of terrestrial C stocks; and
- conservation of existing C stocks (e.g. through reduced deforestation, devegetation and land degradation).

Terrestrial ecosystems also provide food, fuel, shelter and other services and environmental benefits. Balances among the many terrestrial ecosystem services, including GHG mitigation opportunites and other environmental services must be addressed if the LULUCF sector is to provide maximum contribution to the goals of the UNFCCC. This need for balance presents a multi-dimensional challenge to land management.

[2] In addition to the five opportunities listed, LULUCF acts to remove CH_4 from the atmosphere and impacts local and regional climate, either aggravating or providing opportunities to mitigate the effects of climate change.

There are three further special characteristics of the LULUCF sector, namely *saturation* which limits biological sequestration potential (but not provision of renewable energy or wood products), *non-permanence*, and the *degree of human control.*

Saturation

Saturation, or limitation of biological carbon storage potential, occurs because carbon sequestration through land-based activities is limited by the amount of available land and by the activity-specific and location-specific amount of carbon that can be stored or protected on a unit of land. There are differences in the magnitude and timing of changes in carbon pools which depend on the nature of the pool (e.g. vegetation, dead wood, soil) as well as on climate, topography, soil type and past management. For example, carbon in tree biomass can continue to accumulate for up to several centuries as shown in examples of old-growth forests. Stores of carbon in dead wood will continue to increase even after the carbon stocks in live trees have stabilized, because these trees will eventually die and contribute to this pool, and dead wood can persist for very long time periods. Accumulation of carbon in some soils may continue even longer. The saturation limits of the overall sector can be extended if carbon in long-lived harvested wood products is increased. However, this is may also be constrained, for example, by limited demand for housing, the maximum fraction of wooden houses at any given time, and the amount of wood per house.

Saturation is a critical issue in determining the degree to which particular land management activities can contribute to meeting specific CO_2 stabilization targets. The term "saturation" is used very loosely to indicate that it is currently believed that, in the absence of some major disturbances that will reduce carbon stocks at large scales, the sink strength will approach an equilibrium – i.e. net increase or loss will be close to zero at some point if averaged over sufficiently large temporal and spatial scales.

Given the high levels of uncertainty, the saturation issue can be summarized as follows:

- Terrestrial carbon stocks are likely to continue to increase over the next few decades due to atmospheric and climate change and due to the age-class distribution of current forests;
- The associated carbon removals cannot continue forever as sink mechanisms and pools saturate; some have suggested that the terrestrial sink may even become a carbon source within this century (Cox, 2000; Cramer et al., 2001; Kauppi et al., 2001, Canadell et al., 2005); and
- In places where the currently observed removals are largely due to forest regrowth of abandoned agricultural lands*,* saturation may occur on time scales within present or next generation climate change agreements and targets, and may occur sooner than saturation for forests where the sink activity is largely due to CO_2 fertilization, N deposition, or other climate change effects.

The IPCC Third Assessment report estimated that 12-15% of fossil-fuel emissions through to about 2050 could be offset by improved management of terrestrial ecosystems globally (Sathaye and Bouille, 2001). This estimate is a measure of the technical potential but does not take account of opportunity costs and other barriers to implementation. The economic potential is likely to be much smaller (e.g. McCarl and Schneider, 2001). It depends among other factors on the incentives given to landowners. The estimate by Sathaye and Bouille does not include the current, so-called residual carbon uptake[3] in terrestrial systems, estimated at about 2.3

[3] It is called the residual sink because it is calculated as a residual from the difference between sum of known carbon sources and sinks, and the rate of carbon accumulation in the atmosphere.

GtC/yr (Prentice et al. 2001). This residual carbon uptake is generally assumed to be the result of factors such as nitrogen and CO_2 fertilization, changes in climate, recovery from past, more intensive management of lands, and other recent management decisions not dedicated to C sequestration. Human management activities specifically designed to enhance or protect carbon stocks will provide climate benefits independently of whether the residual terrestrial biosphere sink increases or declines.

Non-permanence

Non-permanence [4] concerns potential reversal of carbon sequestration in the biosphere. Management changes may increase the carbon stocks on a given area of land, but these increases can be reversed either by natural causes (fires started by lightning, disease etc) or through land-use decisions. The reverse is also true – a release (e.g., through a fire) can be followed by re-growth of the trees. There is no real parallel to this potential reversibility in conventional fossil-fuel use[5].

The combustion of fossil fuels, unless the resultant carbon dioxide is captured and sequestered in geological formations, always leads to CO_2 emissions to the atmosphere. These emissions release carbon from the large, geologically stable, and potentially utilisable pool of fossil fuel resources. Human actions control the rate at which fossil fuels are utilised, but any release cannot generally be reversed, just as any reduction in the release (e.g. by introduction of more efficient machinery) would usually not be reversed. If fossil-fuel use is curtailed by reduced use, this reduction is not lost even if the emission-saving project were to be terminated at some time. Any reduction, once achieved, remains permanent.

For parties with emission limitation commitments (Annex B countries) the Kyoto Protocol accounts for the non-permanence of carbon stocks on lands subject to Articles 3.3 and 3.4 through the annual reporting of greenhouse gas inventories. These inventories ensure that any emission of CO_2 will be reported and, hence, will be accounted for in the balance of emissions and removals. Non-permanence became a specific issue in the context of the Clean Development Mechanism (CDM), a mechanism used to encourage emission reductions and removals in developing countries. These countries do not have emission limitation commitments. As a consequence they are not required to account for any re-emission of carbon to the atmosphere, even if, as the rules permit, an increase in carbon stock in their country has been used by an Annex B party to meet its commitment. To solve this, carbon credits from CDM projects are temporary; upon termination of a LULUCF project or upon release of the sequestered carbon back to the atmosphere, the Annex B Party that used the credits replaces them with other credits equivalent to the amount of carbon deemed to have been re-emitted.

Although the reporting requirements ensure that losses of carbon stocks will be accounted for, non-permanence can expose countries with commitments that include LULUCF to considerable risk. The relatively limited scope of LULUCF activities agreed to under the Kyoto Protocol and the Marrakech Accords means that the non-permanence risk associated with LULUCF activities is generally fairly small for the first commitment period. However, it

[4] "Non-permanence" is not about the fact that individual trees in a forest stand die and decompose, or that a forest stand within a forested landscape can be harvested - such events do not necessarily mean a loss of carbon stock in the entire forest which can consist of many stands. Rather, "non-permanence" is about the possible net loss of carbon at the project, landscape, regional, or national levels. Such a loss can be, for example, due to human decision to convert the land to other land use, or due to large-scale disturbances such as fire, pests, insects or storms. The difference is that whereas the life of individual trees is limited, the carbon stored in forest landscapes is not necessarily non-permanent. Non-permanence is thus not a certainty, only a possibility.

[5] Geological sequestration of fossil fuel emissions is potentially reversible, although the risk of loss per unit time from a well - designed geological reservoir is likely to be very low.

may be an issue for Parties that elected forest management under Article 3.4 and have ecosystems frequently affected by fire or subject to El Niño cycles.

Some suggest that the biosphere might become an overall net source within 50 to 100 years when the effect of climate change on terrestrial ecosystems is taken into account (Cox et al. 2000, Fung et al., 2005). For example, the warmer the planet gets, the greater the chance that certain carbon pools will become unstable and emit large quantities of CO_2, e.g., from soils, particularly frozen soils, peat lands, or more frequent fires.

If the global community were to adopt *full carbon accounting*[6], as opposed to the more limited approach adopted by the Kyoto Protocol first commitment period, then the risk associated with non-permanence could significantly impact countries' ability to meet commitments, while, on the other hand, the integrity of the atmosphere would be preserved better. Under some future commitment regimes, the degree to which accounting for LULUCF is limited versus more comprehensive may affect the degree to which the integration of LULUCF into an agreement can be treated as mandatory.

The influence of natural effects and the controllability by humans

The *influence of natural effects and controllability by humans* refers to the fact that many natural phenomena influence increases and decreases in carbon stocks; consequently human efforts are constrained by phenomena over which they have only limited control. For example, an area might be planted with trees, an initial human action, but the subsequent growth of those trees may be affected by drought; storms; diseases; insect attacks; and changes in temperature, rainfall, CO_2 concentration, or atmospheric nitrogen deposition. These factors are largely beyond the control of land managers, although their effects on tree growth may be modified by management decisions such as choice of species, planting density, thinning regime, pest and fire control or fertiliser addition. In essence, natural factors are the framework within which the additional human measures operate and form a baseline against which carbon management efforts should be measured.

In contrast, fossil-fuel use is influenced less by natural effects, although changes in weather and climate can impact those portions of fossil fuel use devoted to space heating and cooling and to irrigation. Also, humans have greater control over use of fossil fuel, at least over the longer term, as decisions can be made to increase the use of carbon-free or carbon neutral energy sources.

Already during the negotiations on the Kyoto Protocol and Marrakech Accords concerns emerged that unless reporting and accounting for ULUCF was restricted to direct results of human activities, a significant part of the residual uptake might be counted as part of the actions undertaken to meet commitments. The size of the residual LULUCF uptake (2.3 GtC/yr) compared to mitigation efforts sought in other sectors had an important influence on LULUCF negotiations. The difficulty of dealing with the interplay between natural phenomena and human efforts in LULUCF remains one of the most difficult issues under discussion. This is particularly the case since the IPCC, on preliminary inspection, sees no prospect of comprehensive methodological advice for factoring out indirect and natural effects (which can be both positive and negative) on carbon stock changes from direct effects of human actions, at least in the short or medium term (IPCC, 2003). This special issue includes a paper that revisits the "factoring out" issue.

[6] In the context of this paper, full carbon accounting is the inclusion of emissions and removals on all managed lands, in all pools, and of all relevant greenhouse-gases, without temporal interruption.

3 LULUCF in the first commitment period

The main features of the agreement as negotiated from Kyoto to Marrakech (1997-2001) are that the carbon accumulations and losses from LULUCF from the following areas must be included in the commitments of Annex B countries:

- Carbon stock changes and non-CO_2 emissions between 2008 and 2012 on new forest areas (Afforestation and Reforestation, AR) created since 1990 or deforested (D) since 1990;

Countries may also elect to include any of the following activities to meet commitments:

- Carbon stock changes and non-CO_2 emissions between 2008 and 2012 on areas subject to forest management, up to a cap that is, in most cases, a fraction of the anticipated uptake; and
- Carbon stock changes and non-CO_2 emissions between 2008 and 2012 on areas subject to cropland management, grazing-land management and revegetation, relative to carbon accumulations and associated greenhouse gas emissions from these activities in 1990.
- Afforestation and reforestation projects in non-Annex B countries agreed under the terms of the Clean Development Mechanism (CDM), up to a limit of 1% of the Annex B country's total emissions in 1990.

The ARD activities are conceptually long-term changes from non-forest to forest, such as the conversion of croplands or grasslands into forests, or vice versa. Wood harvesting is not considered to constitute deforestation unless it is followed by a change in land use. Emissions caused by deforestation occur in the year of the disturbance; however removals (stock increases) resulting from afforestation and reforestation occur over an extended period of time. Consequently, the restriction on what can be used to meet commitments – to carbon stock changes resulting from activities undertaken since 1990 - causes a bias towards emissions from deforestation, particularly in the first commitment period[7]. This results in a peculiar situation for some countries: even though their forest areas and carbon stocks may be increasing, they may nonetheless incur a net debit due to deforestation that occurs within the commitment period and exclusion of removals that are resulting from pre-1990 AR. This situation eventually required special treatment in the negotiations.

Under Article 3.4, countries may choose to account for carbon stock changes due to forest management (FM), cropland management (CM), grazing land management (GM) or revegetation (RV). If a country has elected to account for any of these activities, it must account for carbon stock changes on all lands subject to these activities.

Table 1 gives a broad summary of the main land-use activities included in the Kyoto Protocol's first commitment period. The matrix only refers to managed lands, since unmanaged lands are excluded from UNFCCC inventories and from Kyoto Protocol accounting. Revegetation and devegetation are not shown in the table, as they do not necessarily lead to any distinct change from one land-use category to another. For example, revegetation can occur in croplands and grazing lands, but also in other lands. Revegetation and devegetation are limited to categories

[7] Deforestation before 1990 will hardly have any effect on GHG emissions and removals in the commitment period, because deforestation activities only have short-term effects on carbon stocks. Thus, the exclusion of pre-1990 deforestation activities has no major impact. In contrast to deforestation, afforestation or reforestation prior to 1990 can have a large impact on removals for many decades because of the slow growth of trees. Therefore exclusion of AR before 1990 has a significant impact on GHG emissions and removals reported in the commitment period.

where both the initial and the final land use are non-forest. Only revegetation is an eligible Kyoto activity.

Table 1: Summary of LULUCF activities in the first Commitment Period of the Kyoto Protocol

		Final land use		
Initial land use		**Forest**	**Cropland**	**Grazing land**
	Forest	FM	D	D
	Cropland	*AR*	CM	GM
	Grazing land	*AR*	CM	GM

The activities shown in italics in the table are also eligible as CDM projects, undertaken in developing countries. For reasons discussed below, the most significant omission in the CDM is the ineligibility of a reduction in deforestation, which could be quantitatively more important than the activities that are eligible.

Addressing LULUCF's special characteristics in the current Kyoto Protocol rules

A: The Residual Uptake and Limitation to Results of Direct Human Actions

Emissions from industrial processes and use of fossil fuels can be estimated or measured with reasonable confidence, particularly in countries with emission targets (Annex B countries under the Kyoto Protocol). However, even after inclusion of known biosphere sources and sinks, reconciliation of known increases in atmospheric CO_2 concentrations with known fossil-fuel emissions implies an additional very large residual uptake (2.3 GtC/yr) in the terrestrial biosphere. This residual sink is very large compared to the mitigation efforts required for countries to meet their commitments under the Kyoto Protocol. This had an important influence on LULUCF negotiations. It is not known how much of this residual uptake might be found to be occurring in Annex B countries. In particular, there was concern that some Annex B countries might be able to meet their commitments solely or largely through finding a significant portion of this uptake within their national boundaries. This would relieve them of the need to make serious efforts to reduce emissions from fossil fuel use. One of the ways in which this concern was addressed was by limiting the use of LULUCF activities to "direct human-induced" effects on carbon stocks. The limitation to direct human-induced effects also served as part of a compromise between Parties that wanted the Kyoto Protocol to focus on emissions from fossil-fuel sources and those who felt that the terrestrial biosphere should be included.

B: Net-net accounting

Under the Kyoto Protocol emissions and removals from cropland management, grazing land management, revegetation during the first commitment period are compared with emissions and removals from these activities during a previous period (base year or base period). This is called net-net accounting. When net-net accounting is used, any long-term trend in carbon fluxes due to increased temperatures, CO_2 levels or nitrogen deposition will tend to cancel out between these periods. Consequently, net-net accounting, as shown in Figure 1, reduces the likelihood of removals from indirect and natural effects entering the accounting. If emissions to the atmosphere are reduced over time (line C), if removals from the atmosphere can be

increased over time (line A), or if emissions can be turned into removals (line B), such "improvements" to a Party's overall emissions profile will assist it in meeting its commitment.[8]

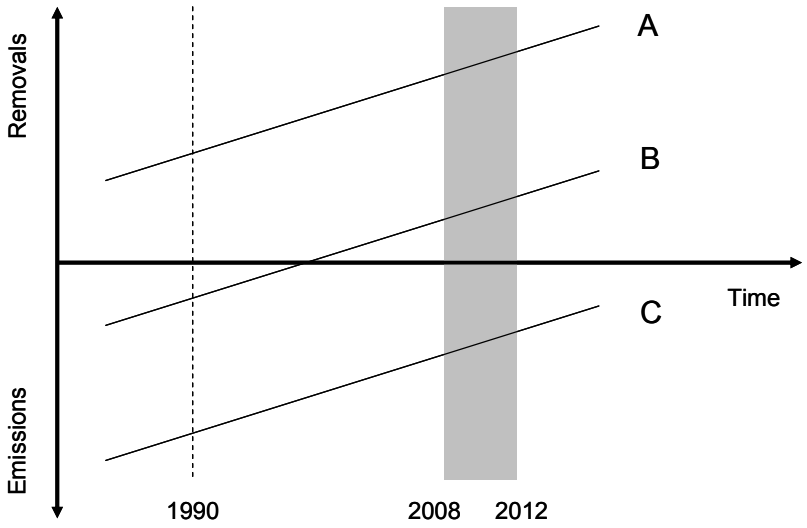

Figure 1: Net-net accounting on croplands and grazing lands.
Three scenarios of emissions or removals of carbon in cropland and grazing land management. Net credits are calculated as the removals or emissions in the commitment period (2008-2012) minus the removals or emissions in 1990. Any of the three lines above, showing three scenarios of the time path of carbon emissions and removals, would lead to net credits under Article 3.4 "cropland management" or "grazing land management". If the lines were decreasing with time, this would lead to a debit under net-net accounting.

Most croplands and grazing lands are subject to human activity every year. Further, it is possible to significantly influence the rate of emissions or removals from croplands and grazing lands within the time frame of a commitment period or two. Since the results of human activities on the cropland and grazing land base emerge within a short time, use of these results to contribute to commitments is relatively straightforward. Croplands are thought to be a source of emissions in many countries (Janssens et al., 2003) and even in countries where croplands are a sink there are opportunities to increase its strength. Since changing the management of a cropland site can change a source of CO2 into a sink or increase sink strength relatively quickly, there is a short-term opportunity to reduce this source of CO_2 and to create, or enhance a sink on these lands. In short, because most countries could improve their emission profile on crop and grazing lands in the near-term, the majority of Annex B parties to the UNFCCC found net-net accounting acceptable for croplands and grazing lands.

Issue 1: Net-net accounting and saturation

Net-net accounting implies that once the mitigation benefits of a LULUCF activity declines, e.g. if the emissions increase or sequestration decreases (the lines in Figure 1 slope down over time); the emission increase or sequestration loss will have to be compensated by other measures. For example, under net-net accounting, if a country has a non-uniform forest age-class distribution then, as the dominant age class approaches maturity, the rate of sequestration by the forest will decrease. As a result, the country may have a debit under net-net accounting caused only by the natural consequence of the existing age-class distribution.

[8] An emission is a negative change in a terrestrial carbon stock, and a removal is a positive change (increase) in a terrestrial carbon stock.

In many Annex B countries conservation policies were initiated decades ago, and many forests could be reaching saturation. In this situation net-net accounting would cause debits even without a country having taken any adverse land-use decisions. Therefore gross-net accounting was adopted for the 1st commitment period under the Kyoto Protocol.

C: Gross-net Accounting

Gross-net accounting only considers emissions and removals during the commitment period without comparing the emissions and removals with a previous time period. If a LULUCF activity leads to net emissions in the target period, these emissions must be added to emissions from fossil fuels and other sources in determining total emissions for compliance with caps. If the LULUCF activity leads to net removals in the target period, irrespective of the carbon flows in the base period, these removals can be subtracted from emissions from other sources in determining compliance with targets.

Gross-net accounting will therefore assist in meeting targets even where LULUCF removals from an activity are diminishing over time. On the other hand, even if LULUCF emissions are being reduced over time, the Party may have debits under gross-net accounting.

The Kyoto Protocol uses gross-net accounting to measure the impacts of forest management activities in the first commitment period.[9]

Issue 2: Gross-net accounting and natural and indirect effects

Gross-net accounting raises more concerns about the impacts of indirect and natural effects, and effects of past management, than net-net accounting. Since gross-net accounting does not compare rates of sequestration, there is no cancellation effect between the base period and the commitment period. Natural and indirect effects such as CO_2 fertilization, responses to other aspects of climate change or changes in carbon stocks resulting simply from the existing age-class distribution can result in carbon sequestration in the commitment period without any action on the part of land managers. Such "unearned" increases are considered windfall credits. Windfall credits are particularly problematic because, if allowed to count toward commitments, such LULUCF removals could be large compared to Annex B countries´ emission reduction commitments in the first commitment period. To address this problem, given that gross-net accounting was to be used for forest management under the Marrakech Accords, there was an agreement to exclude indirect and natural effects. This understanding was expressed in the guiding principles statement saying that "accounting excludes removals resulting from: (i) elevated carbon dioxide concentrations above their pre-industrial level; (ii) indirect nitrogen deposition; and (iii) the dynamic effects of age structure resulting from activities and practices before the reference year[10].

In the case of forest management, the Kyoto Protocol limits the extent to which removals can be used to meet commitments, as a proxy means to factor out indirect and natural effects.[11] For

[9] For Article 3.3 AR activities, a "quasi gross-net accounting" was achieved by using the *since 1990* restriction.

[10] Note that this principle was deemed to be met in the first commitment period by the "since 1990" restriction on afforestation and reforestation (Article 3.3) and a cap placed on credits from forest management under Article 3.4.

[11] In the agreement reached at the resumed session of COP6 in Bonn in June 2001, in order to avoid windfall gains from indirect, natural and pre-1990 effects, gross-net accounting for forest management under Article 3.4 was subjected to a cap equal to 15% of projected removals, or 3% of base year emissions, whichever was less (Figure 1a). There are negotiated exceptions to this rule, but the aim was to reduce the likelihood that the residual uptake would enter the accounting system and, in terms of overall magnitude, it was seen as successful.

afforestation and reforestation, it can be argued that in the absence of these activities no or little carbon stock increase would result from indirect and natural effects, or pre-1990 age-class effects. Therefore, no further "factoring out" measures were deemed necessary.

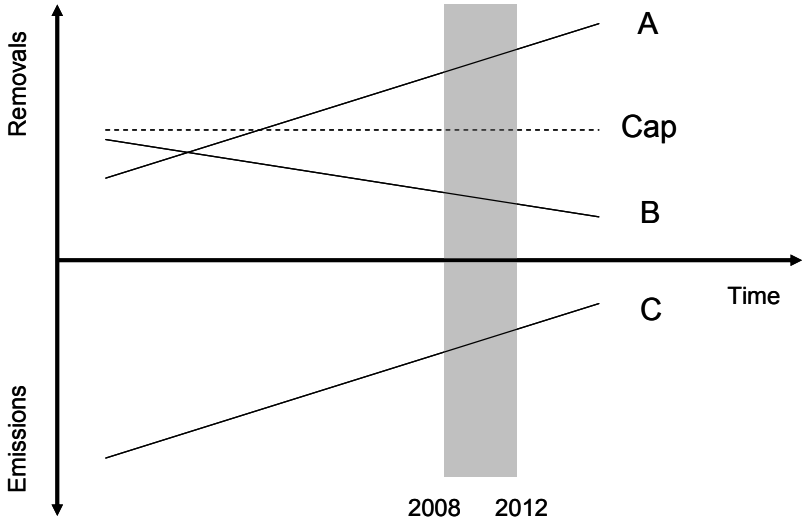

Figure 2: Gross-net accounting on forest management lands

Actual removals of carbon (in tonnes C/year) in forest management and cap on credits that a country can use for compliance. If forest management results in an emission (i.e. line C), then debits occur. However, it is likely that a country would not elect forest management, unless a net removal by managed forests is expected (lines A or B). In case A the credits are limited to the Cap. In case B, the credits will depend on the actual amount of removals during the commitment period.

To summarize, net-net accounting is used for the Article 3.4 activities cropland management, grazing land management, and revegetation. Gross-net accounting is used for afforestation, reforestation and deforestation activities under Art. 3.3[12] and for forest management activities under Art 3.4 (Table 2).

Table 2: GHG accounting approaches under the Kyoto Protocol

Art. 3.3 (ARD)	Art 3.4 (FM)	Art 3.4 (CM, GM, RV)	Non LULUCF sectors
Gross-net	Gross-net	Net-net	Net-net

Note: ARD = Afforestation, reforestation and deforestation; FM = forest management; CM = crop management; GM = grazing land management; and RV = revegetation.

D: Bioenergy

The use of biomass for energy is not mentioned as a land-use activity in the Kyoto Protocol and Marrakech Accords, but is recognized through the reduction in fossil-fuel emissions when biomass fuels are substituted for fossil fuels in the energy sector. Even if land use were not directly included in climate change mitigation policies, renewable bioenergy options could benefit from policies targeting the energy sector (Schneider and McCarl, 2004). The same holds true for substitution of GHG-intensive materials by wood or other renewable materials.

[12] Countries for which land-use change was a net emitter in 1990 account for deforestation on a net-net basis.

Issue 3: Bioenergy in the CDM

Under CDM procedures, credits for emission reductions are issued based on reducing emissions compared to a baseline scenario. The current CDM rules state that only emissions from source categories listed in Annex A of the Kyoto Protocol (Energy, Industrial Processes, Solvent and other Product Use, Non-CO2 gases in Agriculture, and Waste) can be factored into the baseline scenario. As a result of this restriction net emissions from forests and woodlands where biomass fuels are produced unsustainably (i.e., with a depletion of carbon stocks) cannot be included in the baseline scenario. This means that activities that reduce emissions from forests and woodlands by improving the efficiency of biomass energy systems in non Annex B countries, or by replacing unsustainable biomass use with other renewable energy sources, are not eligible for generating credits. This is seen as problematic because these projects may present the most significant opportunities to use the CDM for countries that do not heavily rely on fossil fuels, such as many countries in Africa.

In addition to opportunities to reduce emissions from the land base, increasing the efficiency of biomass use can contribute to sustainable development of project areas and the host countries in general. For example, increased efficiency of biomass can: improve health by reducing local and indoor air pollution; reduce the unsustainable exploitation of natural resources; decrease the amount of time spent on gathering fuelwood; assist in reducing erosion; and reduce water quality and supply problems resulting from deforestation (Schlamadinger and Jurgens, 2004). It should be noted that projects that substitute bioenergy for fossil fuels are eligible under the CDM.

E: Avoided Deforestation

For the first commitment period; non-Annex B countries' role in LULUCF mitigation options has been limited to afforestation and reforestation (AR). AR projects under the CDM are restricted to areas that were not forested in 1990 and, like all CDM projects, to those that would not have occurred without the CDM. Unlike other CDM projects, AR projects receive credits that have pre-defined expiration dates (*temporary CERs* and *long-term CERs*). Use of AR CDM credits by Annex B Parties is limited to 1% of their base-year emissions per year.

Deforestation avoidance was not accepted as an eligible CDM activity in the Marrakech Accords because the CDM is a project based approach because it was thought that the leakage [13] from deforestation avoidance projects using project baselines could be very significant and difficult to estimate accurately. The possibility that the scale of carbon credits from deforestation avoidance could be quite large also played a role in the decision to exclude avoided deforestation from CDM projects.

Nevertheless, deforestation in developing countries accounts for nearly one-third of global greenhouse gas emissions. A post-2012 international agreement should include some method for addressing deforestation in non Annex-I countries (or their future equivalent). This has lately been called for by several countries and organizations (Aisi, 2005), using national baselines which could help alleviate concerns a bout leakage.

[13] "Leakage" of carbon emissions refers to a reduction of emission in an accounted project while simultaneously another source, which is not accounted for under LULUCF reporting, is emitting more carbon. As an example, leakage occurs if forests are protected in one area (under Kyoto reporting) and the deforestation formerly scheduled to take place there is then simply transferred to areas not subject to LULUCF reporting.

Issue 4: Deforestation avoidance

Several deforestation avoidance projects have been initiated over the past decade. Most involve the establishment of national parks and are designed and implemented with an integral community programme and landowner involvement to avoid leakage. In addition, some projects introduce sustainable forest management in the buffer zones around the parks to avoid leakage. These projects demonstrate that it is possible to reduce emissions from deforestation if the project is designed properly (Brown et al., 2000; Aukland et al., 2003; Trines, 2004). However, modalities will need to be developed to ensure that the impacts on deforestation are appropriately taken into account. For example, the choice of the baseline can have a major impact on the integrity of credits generated. While project baselines can be more precise than national or regional baselines, leakage is likely to be more substantial at the project than the national level.

The various lessons and concerns from existing non-Kyoto projects for deforestation avoidance mentioned above will also affect any projects or activities towards this end that might be included in a post 2012 agreement. For example, a proposal has been made by Brazilian non-governmental organizations to create a provision by means of which carbon credits could be generated by deforestation-avoidance (Moutinho, 2005; Santilli et al., 2005).

Reduced emissions from deforestation may have significant potential as a mitigation strategy because it can yield large benefits within a relatively short time. However there are associated risks that must be considered when proposing to include such activity in a possible future agreement. This is discussed in a separate paper within this special issue (ref).

Summary

It is not yet clear what the Kyoto Protocol accounting and implementation rules will bring in practice. However, the rules for monitoring, reporting and accounting of LULUCF are quite complex. To some extent this complexity is a result of attempts to address the ways in which LULUCF presents unique challenges: the large scale of potential emissions and emission reductions; the possibilities of saturation and "impermanence" of results; the influence of natural phenomena. The patchwork of different activities, and the need for geo-referenced reporting, at least to the level of broad geographical boundaries, may turn out to require sophisticated monitoring systems. For future periods, many of the reasons for electing such a rather complex approach, which were related to the nature and environment of the initial negotiations, may no longer apply, and considerable simplifications may be possible.

4 Objectives of including LULUCF, and features of successful strategies for reaching these objectives

To assess options for a post 2012 agreement, it is necessary to develop consistent criteria that balance the overall objectives with practical solutions. In the following section we present our interpretation of the climate-related objectives of including LULUCF. In addition, we discuss strategies to meet these objectives.

4.1 Climate-related Objectives of including LULUCF

The ultimate objective of the UNFCCC and all related agreements including future ones that are adopted in conformance with the UNFCCC is to:

...achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.[14]

Other relevant articles require the following:

...To achieve this, such policies and measures should take into account different socio-economic contexts, be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors…[15]

...Promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems…[16]

With this in mind, as far as LULUCF options are concerned, a post 2012 agreement should aim to create and promote incentives that:

A. Reduce major sources of emissions from LULUCF (reduce deforestation, forest degradation, unsustainable logging, etc.);

B. Enhance and expand major carbon reservoirs;

C. Promote the sustainable use of biomass in materials and for energy generation; and

D. Link emission reduction and sink enhancement with adaptation strategies.

4.2 Necessary features of strategies to meet the climate objectives:

This section lists the means and practical considerations that will be important for making progress towards the objectives in Section 4.1. These are more operational in nature but nevertheless important to the success and acceptability of certain LULUCF options in meeting the objectives of a post 2012 climate agreement. Necessary features of options for LULUCF post-2012 are;

1. promotion of participation by

- mobilizing investment for LULUCF activities;
- improving the simplicity and practicality of monitoring and accounting systems;
- acknowledging countries' land-use sovereignty;
- promoting sustainable development;
- contributing towards achieving global equity;
- differentiation, i.e., taking account of countries' differing circumstances[17].

[14] UNFCCC Article 2

[15] UNFCCC Article 3.3

[16] UNFCCC Art. 3.3, Art. 4.1 (a) – (d), 4.2 (a) – (c), und Art. 7.1 (d)

[17] LULUCF options for the post 2012 period must be cognizant of individual countries' rights and objectives. Non-climate objectives may be of more immediate interest to local communities, land managers and other stakeholders than combating climate change itself. Individual countries may also be interested in synergies with

The ultimate purpose of any greenhouse gas mitigation treaty is to modify human behaviour to limit the build-up of greenhouse gases in the atmosphere. If rules are too cumbersome, or if other factors prevent effective implementation of LULUCF projects, then no effective mitigation will be achieved. It is therefore important to assess whether any particular way of implementing LULUCF makes it easy or hinders the taking of effective mitigation.

It is also important to assess whether rules make sense in a wider context, whether they are cognizant of other constraints such as countries' sovereignty over their land area and whether LULUCF activities undertaken for climate-change mitigation are compatible with other international goals such as achieving sustainable development and assisting moves towards global equity. Finally, it has been acknowledged that for climate-change mitigation, countries take on common, but differentiated, commitments. It is important that LULUCF rules ensure that this principle can also be implemented in the LULUCF sector.

2. completeness over time and space by

- complete geographical coverage and inclusion of all significant sources and sinks;
- avoiding cherry picking (space);
- avoiding leakage (space); and
- covering non-permanence (time).

A serious criticism of the rules under the current Kyoto Protocol is that it allows parties to select only those activities through which they anticipate to gain credits while being allowed to ignore other activities through they would incur debits. This is the case through countries' right to freely select their preferred activities under Article 3.4 and under the CDM, where Annex (I or B) countries can select projects with favourable carbon balances while they and the host countries can ignore all other activities that may lead to adverse greenhouse implications. If the aim of a climate treaty is to protect the global atmosphere for future generations, it is important that such loopholes are avoided and that accounting is complete over time and space.

3. incentives for improvements within countries by;

- avoiding windfall credits and
- closing emission loopholes.

Closing loopholes in order to avoid windfall credits is related to the points discussed under 2) above. It is important that these loopholes are closed so that parties have to meet their mitigation commitments through genuine emission reductions in either the fossil-fuel or LULUCF sectors. If commitments can be met without countries taking any genuine action it would undermine the ultimate goal of climate-change mitigation.

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other UN conventions in achieving of LULUCF objectives at local and national levels. Non-climate objectives may include:

- Increasing food security;
- Improving agricultural /forestry productivity;
- Alleviating poverty;
- Reducing desertificiation and soil erosion;
- Reducing loss of, or enhancing, biodiversity;
- Improving water quality and quantity.

It must be noted that LULUCF activities can also have adverse impacts in some of these areas, and individual countries will have to balance these positive and negative effects when designing land-use strategies. Climate-objectives will be just one among many drivers of land use.

4. **practicality and political acceptance through**
    - consistency with inventory guidelines;
    - continuity from current system
    - fairness, transparency and consistency with the long-term goal of climate-change mitigation; and
    - internal methodological consistency (avoid double counting etc.)

Whatever option is ultimately enshrined in international agreements, it needs to ensure that the rules are transparent, fair, internally consistent and contribute to the ultimate goals of climate-change mitigation. It also helps if they are consistent with internationally agreed inventory guidelines and allow an easy transition from the current accounting system.

These criteria 1 through 4, plus the criteria C and D of the previous section will be used in the subsequent papers to evaluate the different LULUCF options. Criteria A and B are not specifically included since fulfilling criteria 1 through 4 automatically insures that criteria A and B are also fulfilled.

In addition to being assessed against the above criteria, any LULUCF accounting option will have to address the following topics as part of its design:

- definitions of inclusion of land and activities;
- eligibility of activities;
- estimation methods; and
- accounting rules.

5 Discussion - An overall framework of possible commitments

As the international community searches for acceptable, useful, simpler, more cost-effect ways to include LULUCF in efforts to address greenhouse gas emissions, it is important to understand that the approach to LULUCF adopted for the first commitment period of the Kyoto Protocol is only one possible approach. In the first commitment period the Kyoto Protocol uses a single, quantitative target. This quantitative target (permissible tons of GHGs emitted) is met through a combination of enhancing removals/reducing emissions by LULUCF and reducing emissions from non-LULUCF sources. In a sense this approach represents one approach within a spectrum of possible approaches. At another end of the spectrum might be an approach that utilized completely separate targets (sectoral target approach) — one for LULUCF and another (or others) for non-LULUCF emissions — and did not allow exceeding a LULUCF target to "count" toward meeting the non-LULUCF target(s) (and vice-versa).

Equally distinct from the Kyoto Protocol approach would be an approach that does not require quantification of improvements in LULUCF, whether through reductions in emissions or increases in terrestrial carbon stocks. Such an approach might be a pure "policies and measures" approach. The universe of approaches can be visualized by using a two-dimensional matrix as shown in Figure 3. As one moves across the matrix horizontally, one moves from a single, integrated target, through separate but linked targets - where accomplishments in LULUCF and non-LULUCF could, to an extent specified in an agreement, be used to meet either target – to targets that are completely independent of one another. As one moves vertically down the matrix, one moves from quantitative through quasi-quantitative to non-quantitative approaches. A quasi-quantitative approach might be one in which countries committed to certain levels of expenditures on improved land management without committing

to any specific GHG result. A non quantitative agreement could, for example, focus on implementation of policies and measures; like the elimination of subsidies for conversion of lands to grazing or providing incentives for establishing plantations. For some countries this type of approach might be an effective, politically acceptable and cost-effective way to participate in an international agreement.

Prior to the Kyoto Protocol, the UNFCCC was based on voluntary commitments that did not achieve the desired goal. The actual system for the first commitment period (Figure 3) provides quantitative, integrated targets only for some parties (Annex B of the Kyoto Protocol). These targets can be achieved by adopting internal policies and measures and through the use of several flexibility mechanisms that enable parties to incorporate non-domestic emission reductions and atmospheric removals to achieve their targets. However, the fact that developing countries – non-Annex B countries - were not required to commit to quantitative targets for the first commitment period has meant that LULUCF efforts in these countries are limited. By opening up the range of approaches to LULUCF within climate mitigation efforts, it may be possible to make greater use of the biosphere in achieving climate objectives than is currently the case.

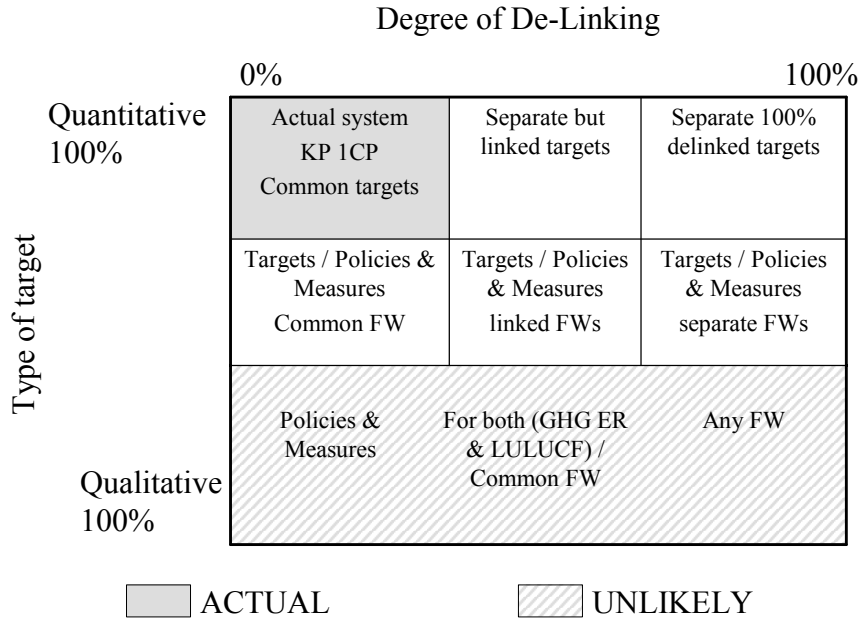

Figure 3: Role of LULUCF – possibilities for the general architecture.

The papers in this special issue address possible changes in the way LULUCF might be part of a system that is adopted for beyond 2012. Some papers propose options that recommend slight modifications of the actual system, staying within the concept of a single, integrated, quantitative target. Others move along the first row of Figure 3, suggesting that LULUCF targets, although quantified, become to varying degrees separated from non-LULUCF targets. More limited discussion of the options that envision at least partial definition of targets in terms of policies and measures is also provided. Included in this latter group are proposals that are starting to emerge which would progress from voluntary LULUCF mitigation to agreements to implement specified policies and measures to achieve some reduction in emissions in Non-Annex B parties, while avoiding commitments to quantitative targets. An example of this approach would be for a country to undertake measures to reduce illegal

logging and/or to reduce deforestation rates, without committing to a specific rate in a specified time period.

6 Conclusions

The current system for including LULUCF activities is certainly not perfect, it was arrived at through a process of complex negotiations which initially focused on sectors other than LULUCF. Now with a better understanding of the problems associated with LULUCF accounting, there is the opportunity to improve the method by which LULUCF activities are included in a post-2012 climate agreement.

In this paper we have presented a synopsis of LULUCF under the Kyoto Protocol and Marrakech Accords. We have drawn attention to the issues associated with the current agreement. We have also presented six criteria for assessing proposed means to address and include LULUCF in a future agreement. In other papers in this special issue we will describe and discuss post-2012 options for LULUCF. These are a result of a workshop on this topic held in Graz, Austria, on May 5-6, 2005[18].

The structure of the workshop was similar to this special issue: After a plenary session that presented and discussed the existing system and criteria for evaluating a future system, the 75 attendees formed four break-out groups to discuss specific topics in detail. The main groupings of LULUCF options discussed were:

Group 1 - Patchwork Approaches: approaches that are similar to the current system of activity based classification and inclusion.

Group 2 - All Lands Approaches: approaches that could be used if accounting included changes in carbon stocks on all managed lands within a country.

Group 3 – Compensated Reductions: approaches and issues that focus on reducing emissions from unsustainable land use such as deforestation in developing countries.

Group 4 – Other approaches, such as delinking of LULUCF from emissions trading, policies and measures.

The meeting was very productive and the tone was one of cooperation and progress. As a result, the remaining papers in this special issue were produced.

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[18] www.joanneum.at/carboinvent/post2012/workshop.html

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